Cooperative RS Transmission Scheme on IEEE 802.16j

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE: C802.16j-06/294

Date Submitted:

2006-11-07

Source:

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Venue:

IEEE 802.16 Session #46, Dallas, TX, USA

Base Document:

Available soon

Purpose:

Recommend cooperative RS transmission scheme in response to the call for technical proposals (IEEE 802.16j-06/027) .

Cooperative RS Transmission Scheme on IEEE 802.16j

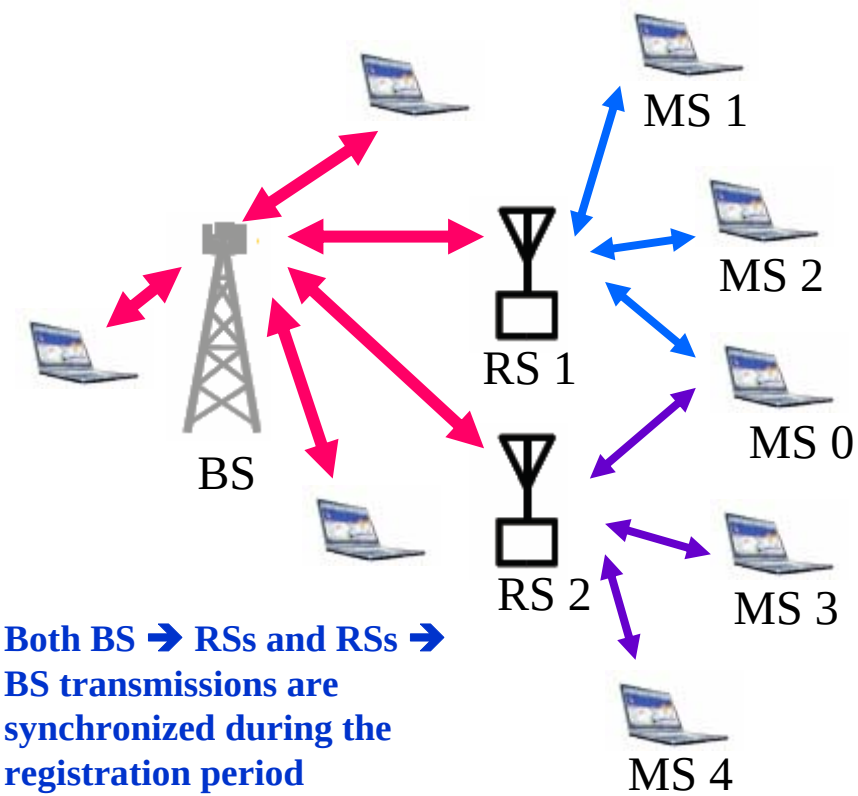
DoCoMo Beijing Labs

Nov. 2006

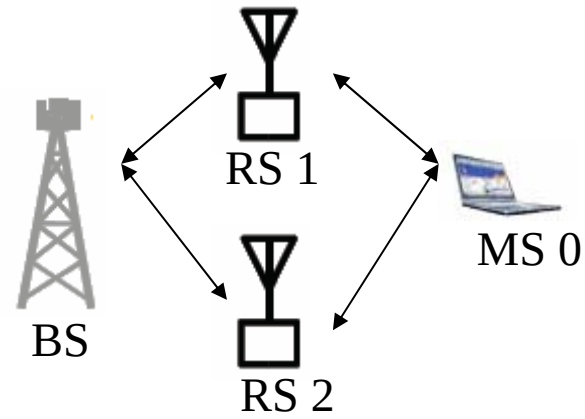
Introduction

- Cooperative transmission can increase network capacity by using distributed MIMO technologies
- The key problems to implement cooperative transmission in the MMR system
  - How to deal with asynchrony among the transmission from cooperative RSs to the SS/MS
  - How to determine which and how many RSs involved in the cooperative transmission

Usage Scenario



Both BS ➔ RSs and RSs ➔ BS transmissions are synchronized during the registration period



Using the proposed method, RS1 and RS2 cooperatively communicate with BS and MS 0.

Directly connected to BS

Connected to RS1

Connected to RS2

Simultaneously, RS1 also relays for MS1 and MS2; RS2 also relays for MS3 and MS4.

Proposed Cooperative RS Transmission

Step 1 (Connection Step):

- Gather information of the received SNR and transmission delay of all possible relay nodes
  - ① In the downlink sub-frame add a cooperative indicator (CI)
  - ② RS_i ➔ MS/SS forward the packet at T_{i0}
  - ③ MS/SS records the received time from each RS_i, T_{i1}, and measures the received SNR_{i1}
  - ④ MS/SS➔RS_i sends back a control packet at T_{i2} including SNR_{i1},$(T_{i2}-T_{i1})$
  - ⑤ RS_i records the received time T_{iE}
  - ⑥ RS_i ➔BS forwards the packet adding $(T_{iE} -T_{i0})$
  - ⑦ BS measures the received SNR_{i2}

Delay i1 = [(TiE-Ti0)-(Ti2-Ti1)]/2

CI: suggested to use 2 bits. (00: No; 11: Yes; 01 and 10 are reserved)

Proposed Cooperative RS Transmission

Step 2(Selection Step):

- BS makes decision on whether cooperative transmission will be executed and which relay nodes are involved in the transmission

i. Initially select all the RSs that can satisfy

$$\begin{cases} SNR_{i1} \geq A * S_1 \\ SNR_{i2} \geq A * S_2 \end{cases} \qquad 0 < A < 1$$

$$S_1 = \max(SNR_{i1}) \qquad S_2 = \max(SNR_{i2})$$

If the number of RSs selected in i. step exceeds a threshold N_R

ii. Only N_R RSs with largest J_i are finally selected

$$J_i = \frac{SNR_{i1}}{S_1} * \frac{SNR_{i2}}{S_2}$$

A is suggested to be 0.3; N_R is suggested to be 2

Proposed Cooperative RS Transmission

Step 3(Information Step):

- All the selected relay nodes are informed with an adjusting table to adjust their downlink transmission timing to be synchronized in the cooperative transmission.

Table 1. Adjusting Table

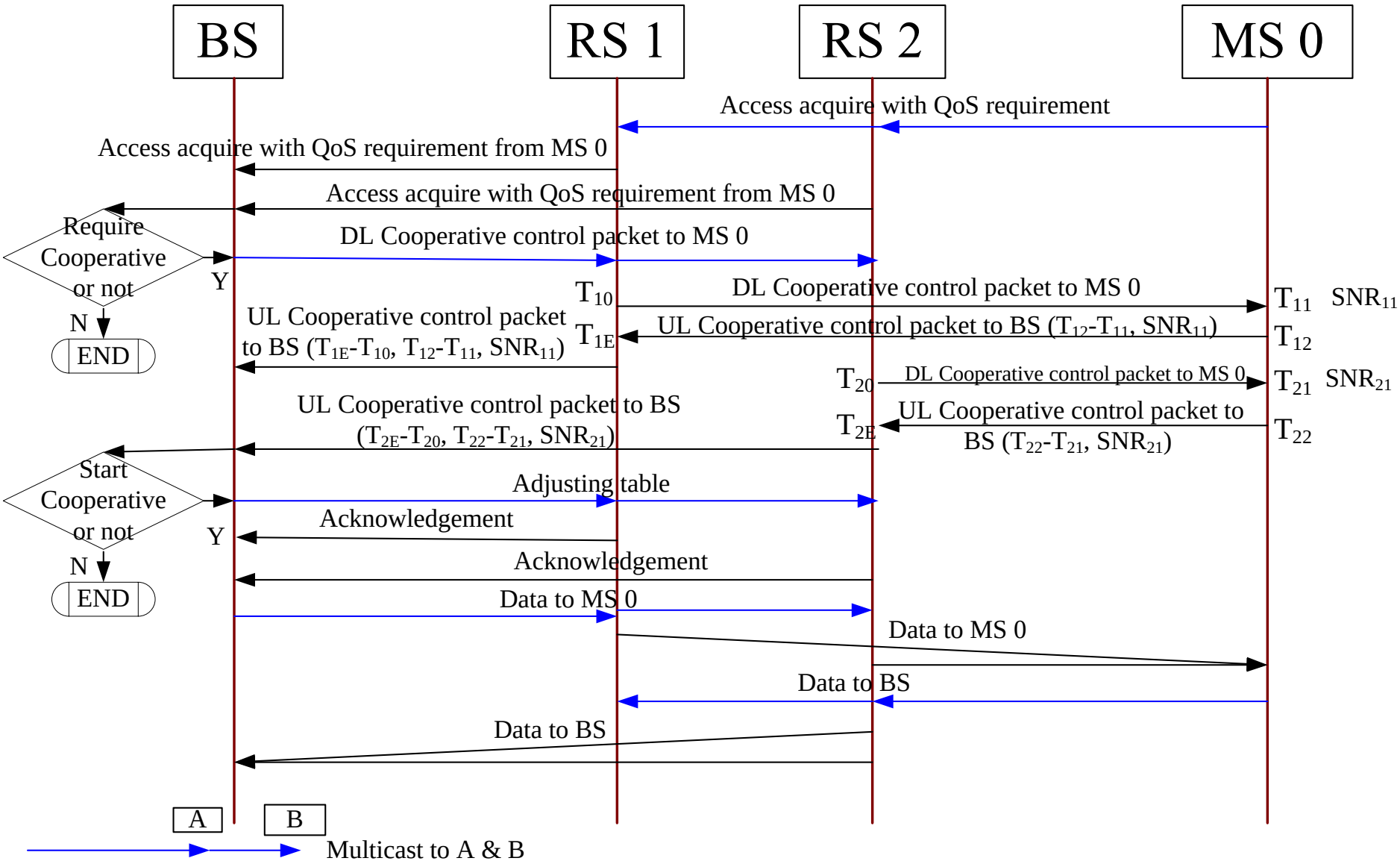
RS ID	Destination MS/SS ID	Total Num. of RS	Order of the RS	Adjust delay i1

Step 4 (Cooperative Transmission Step):

- More than 1 RSs are used for the transmission between the BS and the dedicated MS. Cooperative transmission is in both uplink and downlink.

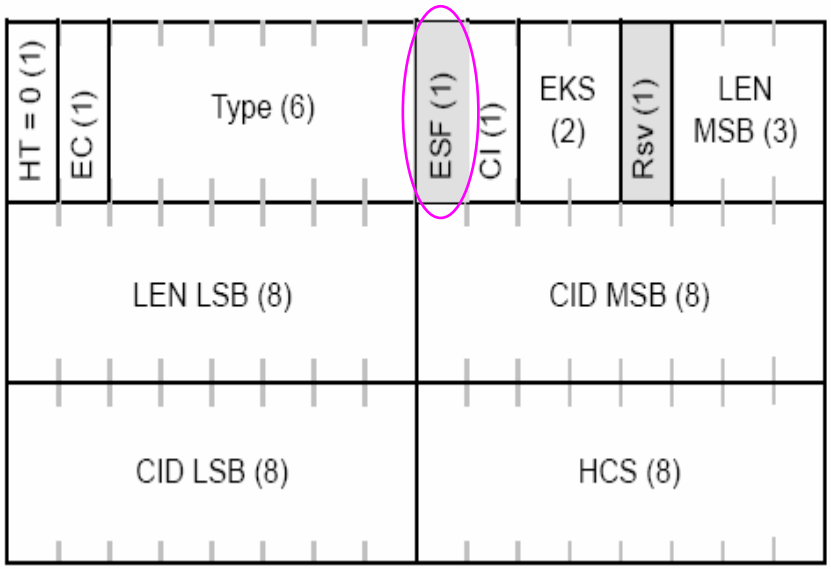
Assume Delay i1 ≤ Delay i2, Adjust delay i1 = Delay i2-Delay i1
Adjust delay i2=0

Message Flow in Cooperative RS Transmission



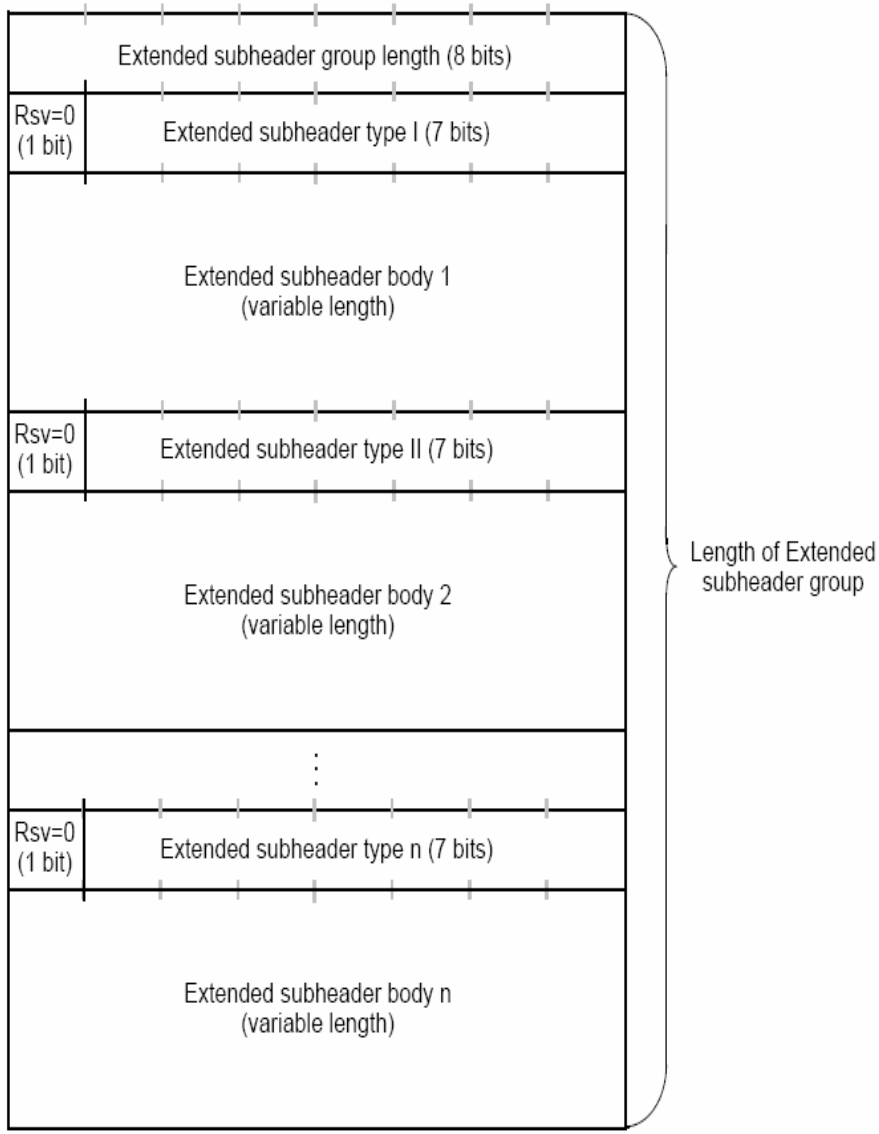
Packet Format in Cooperative RS Transmission

Generic MAC header format



ESF: Extended subheader field.
If ESF = 0, the extended subheader is absent.
If ESF = 1, the extended subheader is present and will follow the GMH immediately.

ESF is used to indicate DL cooperative control packet/ UL cooperative packet / DL RS Adjusting table/ UL RS acknowledgement



Extended subheader group format

Packet Format in Cooperative RS Transmission

Table 1 Description of extended subheaders types (DL)

ES type	Name	ES body size	Description
6	cooperative control packet	1byte	All reserved
7	RS Adjusting table	1 byte	Indicate the payload length in bytes

Payload of RS Adjusting table

1 byte	1 byte	1 byte	1 byte	2 bytes		1 byte	1 byte	2 bytes
DID	NRS	RSID 1	SN 1	AD1	…	RSID N	SN N	AD N

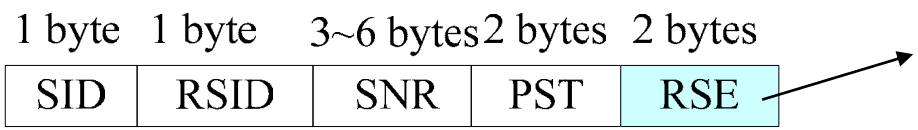
DID: Destination MS/SS ID NRS: Number of RS
RSID i: *i*-th cooperative RS ID SN i: index of STBC assigned to *i*-th cooperative RS
AD i: Retract transmission time of *i*-th cooperative RS (unit ns)

Packet Format in Cooperative RS Transmission

Table 2 Description of extended subheaders types (UL)

ES type	Name	ES body size	Description
6	cooperative control packet	1byte	Indicate the payload length in bytes
7	RS Acknowledgement	1byte	All reserved

Payload of cooperative control packet



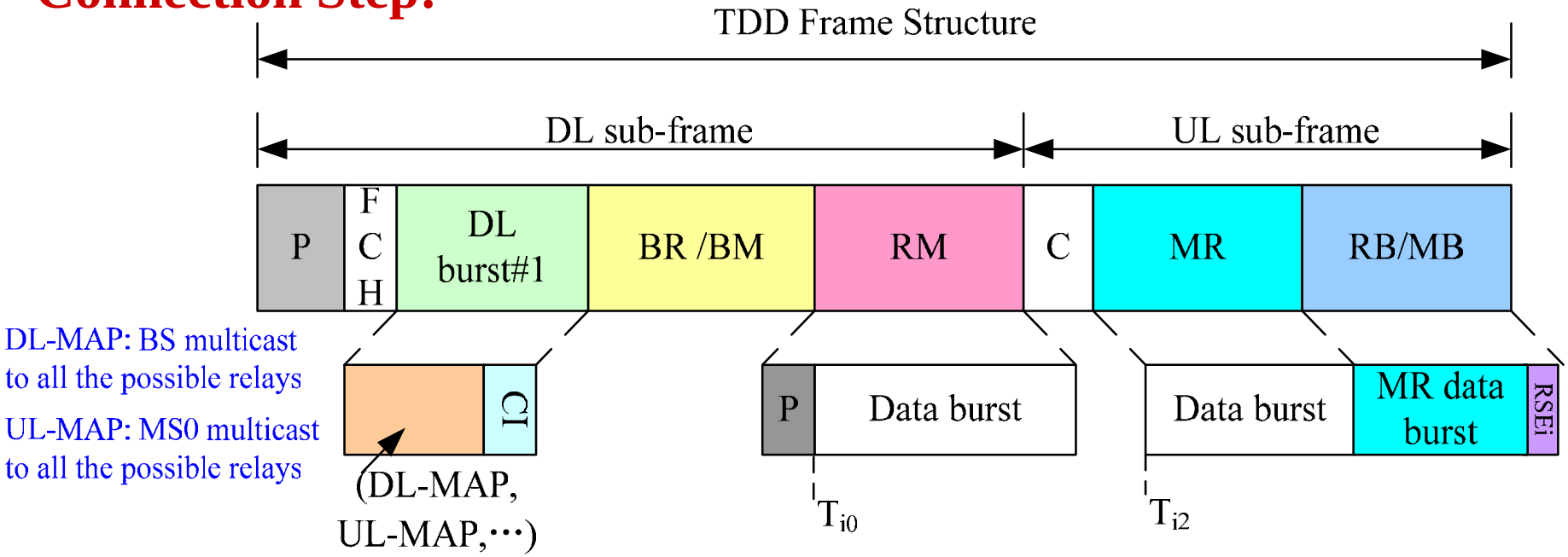
Should be added by the possible RS. The content is T_{iE}-T_{i0} (unit: ns)

SID: Source MS/SS ID
RSID : ID of the possible RS
SNR: Received SNR of the possible RS
PST: T_{i2}-T_{i1} (unit: ns)
RSE: ReServed for Enhence of the possible RS

Where i denotes the ID of RS

Frame Structure in Cooperative RS Transmission

Connection Step:



CI: Cooperative Indicator; Initiate the cooperative connection step

RSE i: including T_{i0} and T_{iE}

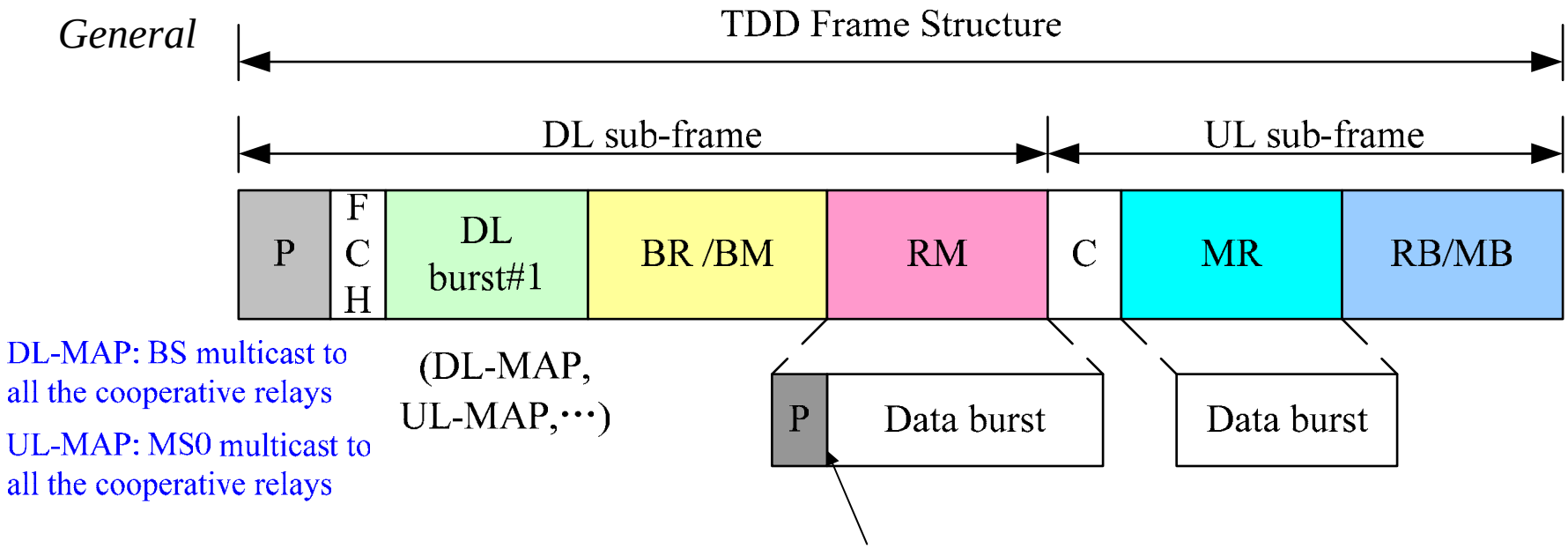
MR data burst: including SNR_{i1}, T_{i1} and T_{i2}

Frame structure in* [1] *is used for illustrations.

[1] C80216mmr-05_005r2, A Recommendation on PMP Mode Compatible Frame Structure.

Frame Structure in Cooperative RS Transmission

Transmission Step:

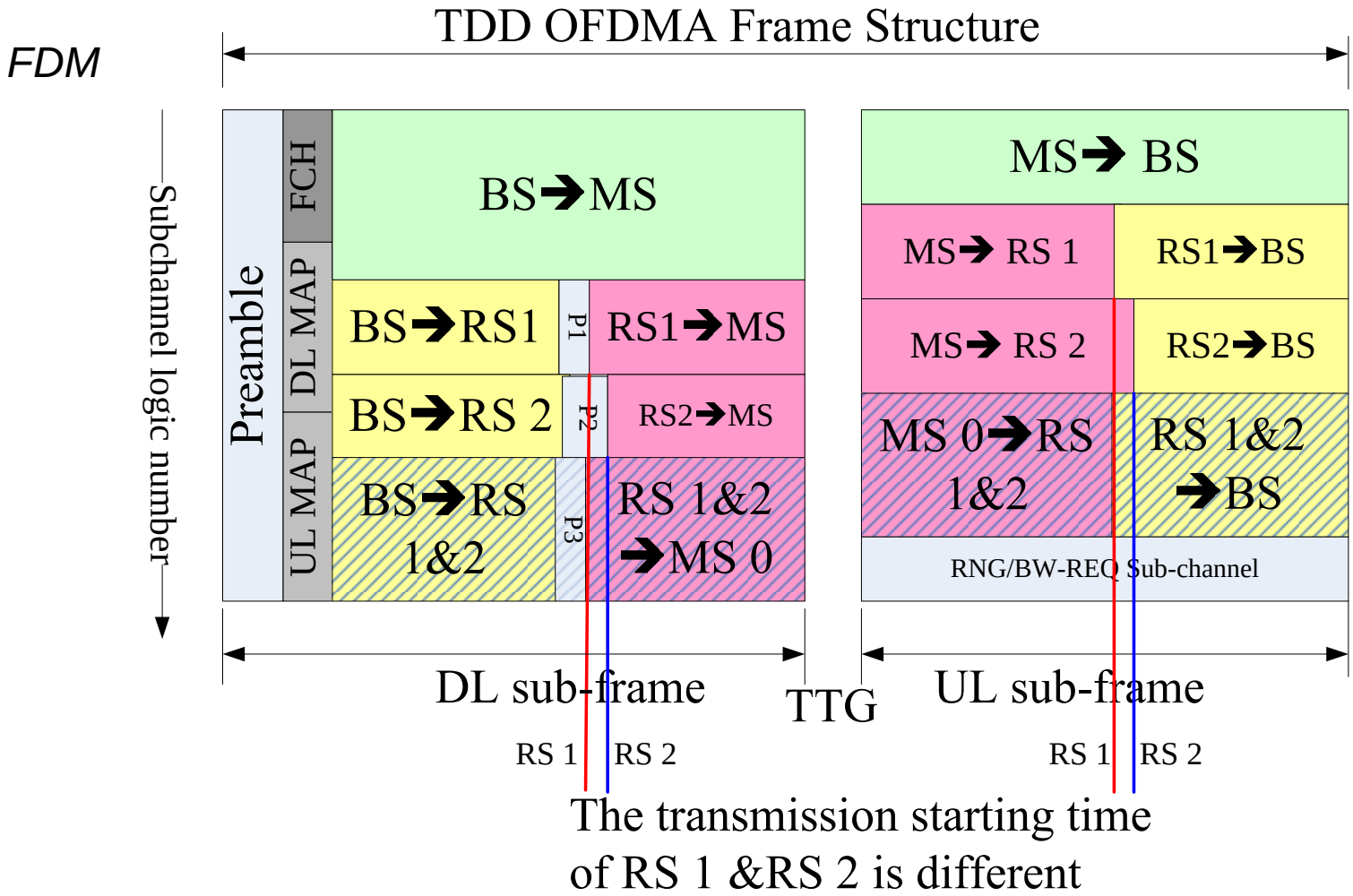


In both uplink and downlink, RS 1 and RS 2 are allocated the same chunk for cooperative transmission and different chunks for other MSs

Frame structure in* [1] *is used for illustrations.

Frame Structure in Cooperative RS Transmission

Transmission Step:



Frame Structure in Cooperative RS Transmission

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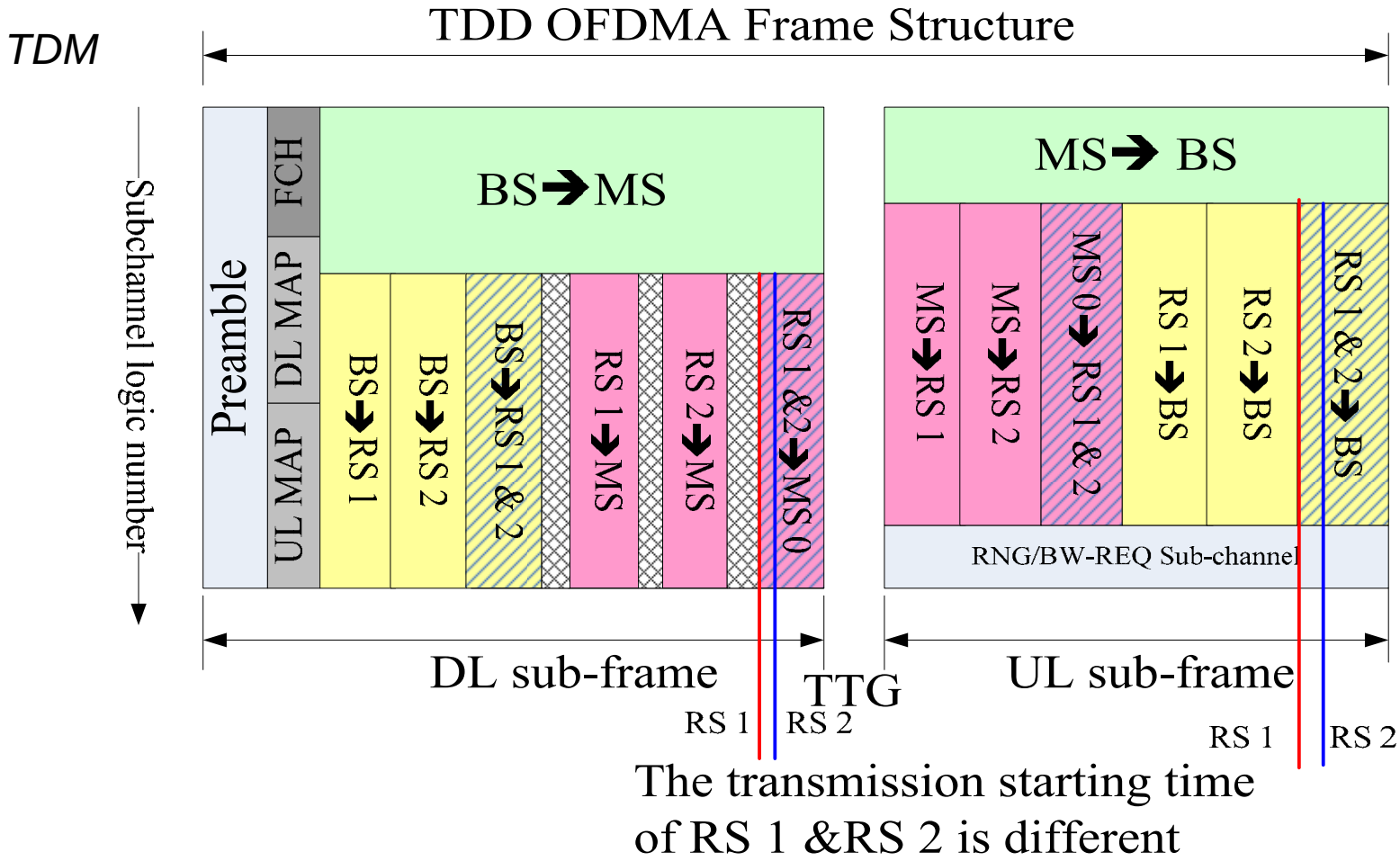

Merits of the Proposed Cooperative RS Transmission Scheme

- The proposed cooperative RS transmission scheme can
  - Realize synchronized transmission.
  - Balance the received performance and the system capacity.
- No hardware change in MS is required when the proposed cooperative transmission is used